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Characterization of Zooplankton Community and Size Composition in Relation to Hydrography and Circulation in the Sea of Japan

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LONG-TERM GOAL

Our ultimate scientific goal is to understand both the biological (e.g., population structure and dynamics and behavior) and physical (e.g., advection, mesoscale physical processes, turbulence) mechanisms that act in concert to produce the observed distributions of plankton in the ocean. Our approach has been to conduct a combination of field, lab, and modeling studies. Field studies define the temporal changes in the distributional patterns of population structure resulting from population growth, swimming behavior, and physical transport. Laboratory studies yield insights into vital rates and behavioral patterns. Modeling ties together the vital rate and behavioral information with the population structure and transport data to determine the mechanisms responsible for observed population distributions.

OBJECTIVES

- 1) To characterize the zooplankton community of the Japan Sea in terms of taxonomic composition and size structure.
- 2) To characterize the scales of variability in the zooplankton of the Japan Sea over distances from centimeters to hundreds of kilometers.

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- 3) To determine the relationship between zooplankton taxa and their associated environmental variables over scales from centimeters to hundreds of kilometers. This information will provide insights into the origins of the different zooplankton taxa.
- 4) To consider the potential flux or exchange of zooplankton into and out of the Sea of Japan through the straits, so that the contribution of physical exchange to resident populations can be quantified.
- 5) To characterize the zooplankton taxonomic composition of the Ulleung Basin eddy in conjunction with the hydrographic analysis of VPR collected temperature and salinity data that will be conducted by S. Ramp.
- 6) To describe the distribution of acoustic scatterers across and along the subpolar front and other hydrographic features, to depths of 200-300 m, through analysis of acoustic backscatter intensity estimated using the acoustic Doppler current profiler that operated during the cruises to the JES.

APPROACH

Our objectives require the ability to obtain high resolution temporally and spatially coincident measurements of both biological and physical characteristics, which then permits description of the coupling between biological and physical distributions and of the distributions of zooplankton and associated variables over scales from centimeters to hundreds of kilometers. To achieve this, we utilize a combination of new technology (the Video Plankton Recorder) coupled with more standard techniques (shipboard acoustic Doppler current profiler, net sampling). We obtained high resolution measurements of the basin-scale distributions of zooplankton abundance and taxonomic and size composition in relation to the hydrography, currents, light, fluorescence, and beam attenuation in the upper water column (80 m) using the Video Plankton Recorder (VPR) in the southern Japan Sea during June-July 1999 from the *R/V Roger Revelle*. The VPR is essentially an underwater microscope which images plankton at two different magnifications. The instrument is mounted on a V-fin which is towed behind the ship, undulating between the surface and a selected depth. Video images and associated hydrographic and biological data are transmitted from the towed vehicle to the ship via fiber optic cable. In-focus images of plankton are extracted from the video and identified to taxa in real time. Plankton abundances and hydrography are plotted in real time. Acoustic Doppler current profiler (ADCP) backscatter intensity data were collected using the hull-mounted ADCP on the *Revelle* during June-July 1999 and also on several other cruises conducted at different periods of the year (spring, winter). We collaborated substantially with Dr. Lynne Talley (SIO), who was chief scientist on the cruise and conducted basin-wide CTD measurements as part of the ONR Japan/East Sea DRI. We are collaborating with Dr. Steven Ramp, who is examining the dynamics of the Ulleung Basin and East Korean Warm Current/North Korean Cold Current confluence using hydrographic data collected with the VPR, to describe the biological-physical associations in this region. We also are collaborating with Dr. Charles Flagg (BNL) who is processing the ADCP data, to describe the spatial distribution of backscatter intensity (a proxy for plankton or nekton abundance) across the Japan/East Sea. The work will provide a better understanding of how boreal and tropical zooplankton communities maintain themselves in a dynamic physical environment.

WORK COMPLETED

The taxonomic and size composition of the zooplankton community in the upper 80 m of the Japan/East Sea was described and mapped in real time using the Video Plankton Recorder during June 17 - July 23, 1999 on Dr. Lynne Talley's cruise on the *R/V Roger Revelle*, surveying over both the northern and southern regions, the Subpolar Front between, and the Ulleung Basin. The instrument sampled between near surface and 80 m for much of the survey with an inter-profile distance of ~7 kilometers and an along-path resolution of centimeters. A total distance of 3562 kilometers was sampled and over 240 hours of video and associated data were collected and processed. Pressure, temperature, conductivity, fluorescence, light transmission, ambient light, P-Code GPS position and time (UTC) and Knudsen Echo Sounder depth data also were logged. Acoustic Doppler current profiler data were collected; velocity data have been entered into a database at Brookhaven National Laboratory under the supervision of Dr. Charles Flagg. During the cruise, hydrographic and taxon specific plankton distribution data were displayed in real time. In addition to the primary sampling with the VPR, fifteen plankton tows were conducted using a 1-m² (mouth area), 150 µm mesh ring net towed obliquely between the surface and 80 m.

Over 90% of the video images collected with the high magnification camera were analyzed at sea; the remaining 10% were analyzed shortly after the cruise. Eight taxa were identified from the low magnification camera; calanoid copepods, *Oithona* (a cyclopoid copepod), copepod nauplii, diatom chains, acantharia, sarcodina, larvaceans, and large protozoa. Identification of the video images from the low magnification camera that were collected along the N-S transect lines is 75% completed. Identification of low magnification images from the Ulleung Basin survey still must be accomplished; this involves extracting in-focus images from ~8 days of video records at actual collection speed (e.g., 2 hours of video per 2 hours of towing), followed by identification of these images to taxa in much faster than collection speed. Silhouette analyses of the plankton samples from the ring net tows (taxa specific sizes and abundances) are completed.

Presently, we are merging the plankton data with hydrographic and velocity data in addressing how the physical environment (fronts, advection, water mass type) influences the plankton communities of this marginal sea. The results of this synthesis will shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea and will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment. We also are considering the plankton composition (taxa specific) and size distribution in the different hydrographic regions and portions of the water column. Preliminary results of these analyses were presented at the 2000 AGU Fall Meeting. Processing of the acoustic backscatter intensity from the ADCP is in progress; we anticipate completion of the processing during October, 2001. We are working towards several papers from these analyses: One describing the mesoscale distribution, size composition, and vertical distribution of zooplankton taxa in relation to hydrographic features using the VPR data, a second describing the zooplankton size, taxonomic, and biomass composition from the net tows, and a third describing spatial and temporal trends in acoustic backscatter intensity.

RESULTS TO DATE

1. The cruise track surveyed at least two hydrographic regions which had distinct temperature-salinity properties: the southern Japan Sea (south of the subpolar front) and the northern Japan Sea (north of the subpolar front).

2. Copepod was the most numerous taxon, representing 50% or greater of the taxonomic composition at all locations. Copepods were proportionally less abundant to the north than to the south of the subpolar front, with nauplii and protozoa becoming proportionally more abundant to the north of the front.
3. Copepod and diatom abundances were inversely proportional across the surveyed region; these changes were associated with hydrographic changes such as the location of the North Korean cold Current.
4. Copepod vertical distribution was associated with the hydrographic structure of the water column but modified by diel vertical migration.
5. The size composition of the plankton, and copepods, varied according to hydrographic region and water mass type. For the high magnification camera, smallest plankton were found below the thermocline in water of less than 5 °C. Most of this latter type of water was found to the north of the subpolar front. By contrast, plankton observed using the low magnification camera from below the thermocline were larger than those observed above the thermocline. As expected, the two cameras imaged different size ranges with larger plankton observed at the lower magnification.
6. Plankton taxonomic composition from the net tows followed the same trends as those observed in the VPR data, with copepods dominating the taxonomic composition at all locations but being proportionally less abundant to the north of the subpolar front.

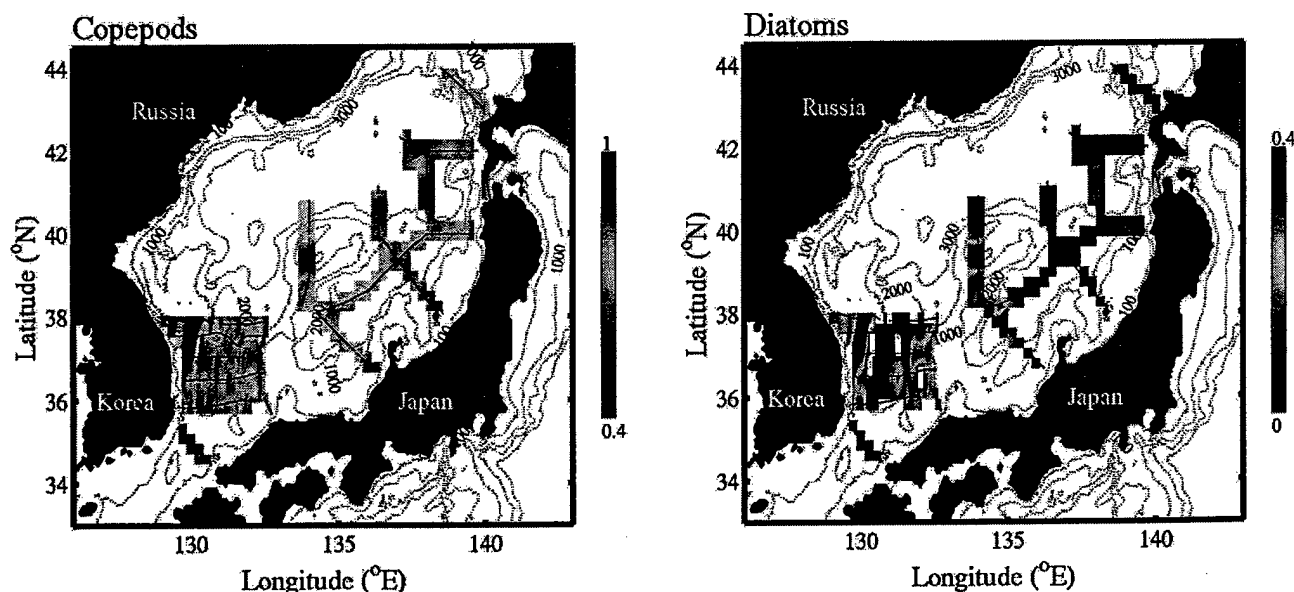


Figure 1. Proportion of copepods (left) and diatoms (right) of total plankton abundance for upper 80 m of the JES from abundances described using the high magnification camera of the VPR. High proportions of copepods are observed at locations where low proportions of diatoms were observed and vice-versa. These transitions were associated with hydrographic features, such as the Ulleung Basin "Eddy" (high copepods, low diatoms) and the North Korean Cold Current (low copepods, high diatoms). [The plots show maps of the proportions as color shading over the surveyed region relative to topographic features.]

Ongoing analyses include: 1) describing the size distribution of taxa in different hydrographic regions, 2) quantifying associations between different taxa and between taxa and environmental conditions, 3) examining the scale of variability of the distributions of zooplankton taxa, 4) incorporating instantaneous velocity measurements collected with the shipboard acoustic Doppler current profiler to estimate of flux of plankton between different hydrographic regions and in and out of the JES, and 5) gaining a greater understanding of spatial and temporal variation in the distribution of plankton across the Subpolar front through consideration of acoustic Doppler current profiler backscatter intensity.

IMPACT/APPLICATION

The proposed study will shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea. We also will gain new insights into the impact of advective input of a tropical community into a boreal region. The mixture of the two communities and the potential establishment of a transitional community along the Subpolar Front will allow us to examine how the affinities of zooplankton communities change in response to advective transport over a broad range of scale and the roles of eddies and meanders in promoting exchange between different planktonic and hydrographic regimes. Such information will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment.

TRANSITIONS

Our findings will allow better predictions of how zooplankton and large phytoplankton abundance patterns change as a function of hydrography and currents in the Japan Sea. More generally, the findings will provide a better understanding of how plankton and physical properties are distributed in relation to each other over a broad range of scales in the vicinity of a sharp biogeographic frontal region. This information then can be used to better understand variability in sound and light scattering properties of the ocean.

RELATED PROJECTS

This work will be integrated with the Japan Sea DRI which involves many investigators in physical and optical oceanography., including S. Ramp (Ulleung Basin and NKCC/EKWC confluence).

PUBLICATIONS

Ashjian, C.J., C.S. Davis, S.M. Gallagher, and P. Alatalo. Characterization of the zooplankton community and size composition in relation to hydrography and circulation in the Sea of Japan. EOS 81: F747.

Ramp, S. R., F.L. Bahr, C.J. Ashjian, C. Davis, L.D. Talley. The mesoscale structure of the Ulleung Basin during June 1999. EOS 81: F767.

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13. Abstract: The northern and southern Japan Sea are hydrographically and biologically distinct, with the southern portion being more tropical/oligotrophic and the northern portion being more boreal/eutrophic. The plankton of the Japan Sea remains poorly understood, particularly with regard to high-resolution description of the distribution of planktonic taxa and environmental conditions. We described the taxonomic and size composition of the zooplankton community and associated hydrography of the JES during the summer of 1999 using the Video Plankton Recorder (VPR), surveying over both the northern and southern regions, the Subpolar Front between, and the Ulleung Basin. The VPR was towed between the near-surface and 80 m for over 240 hours and 3500 km., collecting over 600,000 images of plankton, and coincident hydrography. The distributions of identified taxa and hydrographic characteristics were plotted in near-real time at sea. Plankton also were collected at 15 selected stations using a ring net, for silhouette analysis of taxa and size. Both net tows and VPR data demonstrated that dramatically different plankton taxonomic and size compositions were observed in the various hydrographic re		
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